1.0 OVERVIEW

1.1 Research and Development Responsibilities and Objectives

> Everyone takes a keen interest in what the FAA is doing—the Congress, industry, the media, the public ... that's because aviation touches our lives in so many ways. People rightly demand the safest, most reliable system possible. They expect the planes to be safe, their flights to be on time, and their luggage to be on the carrousel. And they expect peak performance around the clock, day after day, year in, year out.
>
> **— Jane F. Garvey, FAA Administrator, May 21, 1999**

The United States President, Congress, and the American public hold the Federal Aviation Administration responsible for providing a safe, secure, and efficient National Airspace System (NAS). Furthermore, they expect FAA actions and regulations to be effective in improving aviation safety and security while still mitigating the impacts of aircraft noise and emissions upon the environment. Better research and the implementation of effective new solutions increasingly hold the key to meeting the rising expectations of the American people and their Government.

The significance of the FAA's research and development (R&D) will grow in proportion with the demands placed upon it. The FAA's R&D program finds and prepares to field technologies, systems, designs, and procedures that directly support the agency's principal operational and regulatory responsibilities: air traffic services, certification of aircraft and aviation personnel, operation and certification of airports, civil aviation security, and environmental standards for civil aviation.

Safety remains the agency's top priority. While the FAA, NASA, and other R&D sources have introduced many new technologies and procedures over the past 20 years—and the accident rate has dropped dramatically as a result—expectations are constantly being raised. The R&D program supports essential agency initiatives to reduce fatal accidents by 80 percent by the year 2007. Without a major infusion of new technologies and procedures, it will be extremely difficult for the FAA and the aviation community to meet this goal.

To support the agency's principal operational and regulatory responsibilities, the FAA's R&D program is functionally divided into seven areas: Air Traffic Services, Airport Safety Technology, Aircraft Safety, System Security, Human Factors, Environment and Energy, and an overall planning and coordinating function titled R,E&D Program Direction. Each of these areas will be described briefly in Section 1.6 of this Overview and reported on in detail in their respective sections of this Plan.

1.2 Civil Aviation and the Nation

Economic Importance

Technical and procedural insights gained from FAA R&D affect the largest export sector of our national economy. A viable FAA R&D program is critical to ensure the continued safety and efficiency of the air transportation system and, as a result, U.S. technical and economic leadership in international aviation. 1998 estimates (see Table 1) concentrating on just the U.S. scheduled airlines and their associated spending account for 3.2 percent of our Gross Domestic Product (GDP). U.S. aviation industries hope to deliver over 14,000 transport aircraft valued at $1 trillion over the next 20 years. Figures developed in 1993 and not yet updated, estimated that the total effect of aviation and related industries contributed almost 6 percent to the GDP and provided over 8 million jobs.

Table 1: Airline Spending (Air Transport Association of America)

Airline Spending ***For the 12 months ending December 31, 1998***	
Labor Compensation	**(in billions)** $ 33.1
Materials Purchased	**16.5**
Services Purchased	**21.5**
Capital Expenses	**17.2**
Other Expenses	**20.8**
TOTAL DIRECT SPENDING	**109.1**
TOTAL INDIRECT SPENDING	**109.1**
TOTAL INDUCED SPENDING	**54.6**
TOTAL GDP CONTRIBUTION	**$272.8**
AIRLINE SPENDING AS A% OF GDP	**3.2%**

Aviation-related research and development is accelerating in other nations and improving their commercial aviation products. Increased foreign competition is showing signs of eroding our international position. Effective R&D is a major factor determining the leadership and market share in vibrant industries such as aviation.

Forecasted Needs

The FAA forecasts that domestic air carrier revenue passenger miles will increase 3.8 percent annually between fiscal years 2000–2008. (See Figure 1-1) Projections assume that domestic passenger yields will increase 1.7 percent annually over the forecast period, and international air carrier revenue passenger miles and enplanements will increase 5.3 percent annually. The numbers of passengers carried on commercial aircraft will soon nearly double, reaching one billion by 2015. This projected growth will increase the strain on the air transportation system's capacity, safety, and security.

Recent armed conflicts have shown that, without a sense of security, air travelers will change their mode of transportation or dramatically decrease their travel. While statistics may not justify the flying public's fears and concerns, these perceptions become a reality that must be addressed. The FAA R&D program is focusing on developing methods and innovations that will ensure the safety that the public demands.

1.3 Need for Modernization

In the course of the 1990s, many calls have come to the agency to do business differently—some of them from outside the DOT/FAA ranks, and some from within. All of the advocates of change described in this section have contributed to a growing spirit of modernization both in systems and in the operating "culture" of the agency.

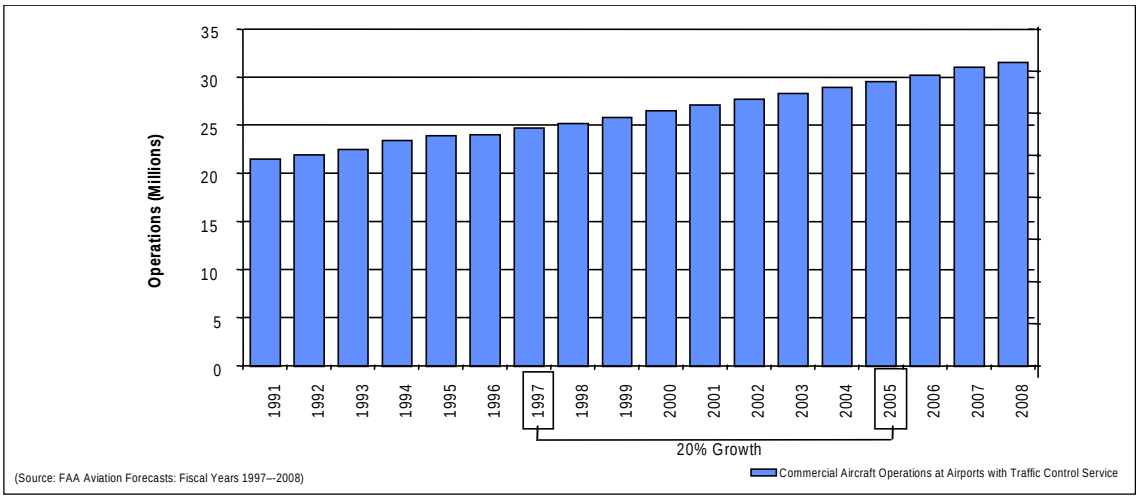

Figure 1-1. Commercial Aircraft Operation

1.3.1 External Motivators

Government Performance and Results Act of 1993

No recent legislation has posed a greater challenge to traditional business practices throughout the Federal Government than the Government Performance and Results Act of 1993 (GPRA). The FAA R&D program's first GPRA challenge was to learn how to apply the terms to its own operating environment. Figure 1-2 illustrates key GPRA concepts as applied to the R&D culture.

The FAA now emphasizes GPRA concepts throughout the National Aviation Research Plan. As shown in the diagram, the R&D program partners with its stakeholders responds to various inputs and provides its customers with outputs that will bring about favorable outcomes. In other words, the R&D program partners with members of academia, industry, unions, and other government agencies; responds to the demands placed upon it; and provides industry, the public, and the aviation community with products, such as regulations or prototype systems, that will solve problems and increase capabilities.

The primary challenge in the FAA R&D process is to understand how emerging technologies should be packaged into outputs that will lead to desirable outcomes. The secondary challenge is to understand and to quantify the impact and influence of emerging technologies upon existing and future conditions. The initiatives described in Section 1.4 show why DOT and its components

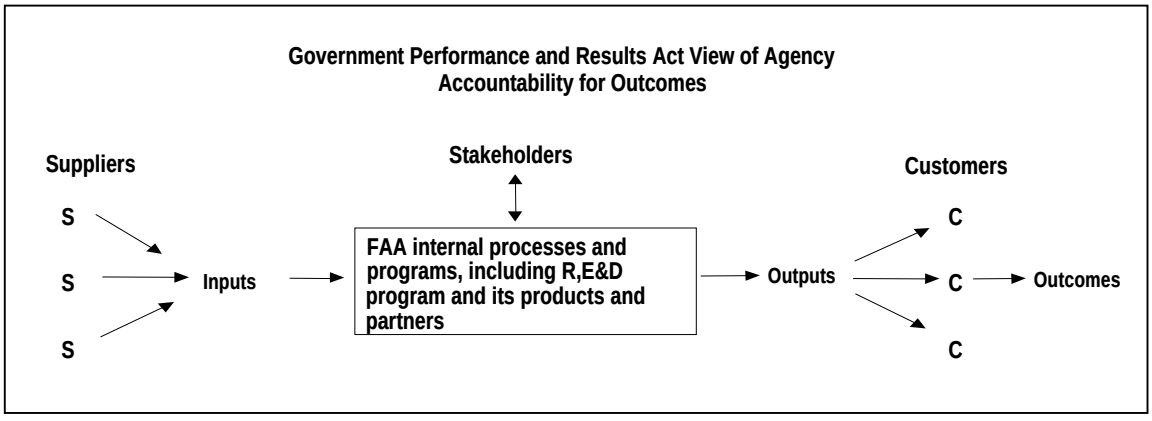

Figure 1-2. FAA R&D Program and GPRA terminology

have earned a good reputation for adhering to GPRA guidelines and principles.

White House Commission on Aviation Safety and Security

In August 1996, White House Executive Order 13015 established the Commission on Aviation Safety and Security. Chaired by Vice President Al Gore, the commission is referred to informally in the aviation community as the "Gore Commission." Included in its initial mandate was the requirement to review the current status of NAS modernization efforts and recommend changes if required.

After presenting its key recommendations on the funding of new aviation safety and security initiatives, the group's final report concluded: "…the commission believes that the safety and efficiency improvements that will come with a modernized system should not be delayed and recommends that the program be accelerated to achieve full operational capability by 2005."

This recommendation represents a significant challenge and opportunity for R&D, one that can be met only with a renewed sense of dedication and expanded partnerships with industry and academia.

President's Commission on Critical Infrastructure Protection

The President's Commission on Critical Infrastructure Protection was the first national forum to address the vulnerabilities created in the new information age. Established in July 1996 by Executive Order 13010, the commission was chaired by aerospace industry leader Robert "Tom" Marsh. Its charter was to provide advice and assistance to the President in finding current and viable means to protect critical infrastructures, including aviation, from physical and cyber threats.

An advisory committee of industry leaders supported the main body, and a steering committee of cabinet-level officials reviewed the final report, *Critical Foundations*, before sending it to the President in October 1997.

National Civil Aviation Review Commission

In its final report (December 1997), the National Civil Aviation Review Commission (NCARC) recommended broad and sweeping changes in the ways the FAA is managed, sets its priorities, assesses and achieves performance outcomes, and is financed. The Commission made five broad recommendations:

- FAA's funding and financing system receive a Federal Budget treatment ensuring that revenues from aviation users and spending on aviation services be directly linked and shielded from discretionary budget caps.
- Air traffic control services be placed in a performance-based organization managed by a chief operating officer and overseen by a board of public interest directors.
- FAA adopt a cost-based revenue stream to support its air traffic system activities, including capital investments.
- FAA operating costs be better managed and controlled and investments in air traffic control modernization be increased.
- The Airport Improvement Program be funded at a minimum of $2 billion annually over the next five years.

1.3.2 DOT/FAA-Internal Motivators

DOT Flagship Initiatives

One hundred and eighty senior leaders from all components of DOT met for two days in February of 1999 as the department's first-ever expanded Senior Leadership Team. Their charter was to identify ways to improve overall cooperation among the various DOT components and ensure consensus on crosscutting issues. The team agreed that the two years ushering in the new millennium posed public credibility issues beyond the transportation establishment's normal day-to-day activities

The results of their discussions form a two-year strategic agenda with its roots in the department's Strategic and Performance Plans—documents judged to be highly responsive to GPRA requirements and intent. The initiatives selected for inclusion in the agenda answered the question: By what criteria will the public judge the overall performance of DOT in the year 2000? Items that made the list became DOT "Flagship Initiatives."

The Flagship Initiatives are almost all "intermodal," that is, they involve more than one major component of the department. They cluster

around five DOT strategic goals: safety, mobility, economic growth and trade, human and natural environment, and national security. In some cases, the Initiatives involving the FAA refer directly to R&D issues, but performance of successful research and development underlies nearly all.

The following DOT Flagship Initiatives directly involve the FAA:

- *Safety*
  - Fatigue/Alertness and other Human Factors Issues
  - Hazardous Materials handling/Incidents
  - Safer Skies: A Focused Agenda
- *Mobility*
  - Free Flight Phase 1
- *GPS*
- *Economic Growth and Trade*
  - Domestic Aviation (various concerns)
  - Free Flight Phase 1
  - Global Transportation
- *Natural Environment*
  - Aircraft Noise Standards
- *National Security*
  - Reduce Flow of Illegal Drugs/Illegal Aliens
  - Implement Gore Commission Recommendations
  - 1999 Federal Radionavigation Plan
  - Peacetime Engagement/Nation-Building Operations
  - Partnership with DOD and other Defense-Related Agencies

FAA Administrator

It will be clear in the descriptions of many initiatives described in Section 1.4 that the Office of the FAA Administrator is firmly behind NAS modernization and its related activities. The following remarks from the Administrator's speeches further illustrate this commitment:

> "The Gore Commission gave the FAA a mandate — modernize the air traffic control system. …. It cannot be business as usual. Let me rephrase that — it will not be business as usual. Our job is too important."
>
> — March 12, 1998
>
> "Success with Free Flight Phase 1 will show that we can do what we say we will do. That we can do what needs to be done — on time and on budget."
>
> — September 30, 1998
>
> "What drives us to work so hard and so well together is that we all know that Safer Skies is absolutely the right approach. This data-driven, prioritized, and measured approach is the best way to enhance aviation safety. Safer Skies is the right thing to do."
>
> — April 15, 1999

R,E&D Advisory Committee

The FAA's R,E&D Advisory Committee (REDAC), established in 1989, advises the Administrator on research and development issues and provides a liaison between the FAA R&D program and those of industry, academia, and other government agencies. The committee considers aviation research needs in air traffic services, airport technology, aircraft safety, aviation security, human factors, and the environment.

Up to thirty members may serve on the Committee. They serve two-year terms and represent corporations, universities, associations, consumers and other government agencies. The FAA's Director of Aviation Research, serves as the executive director of the committee. The REDAC meets two times during the year: in April and in September.

NASA's Aero-Space Technology Advisory Committee and FAA's R,E&D Advisory Committee now conduct joint meetings to establish a framework that allows them to better support interagency R&D modernization goals in the areas of safety, efficiency, and environment and energy.

Recent REDAC recommendations appear in Appendix A of this Plan.

1.4 Recent Aviation Community Initiatives

All FAA initiatives described in this section relate directly to the agency's pragmatic approach to NAS Modernization. In their planning and execution, they are "benefits-driven," involve all facets of the user community, try to lessen implementation risk, and depend heavily upon past, current, and future R&D efforts. In philosophy, the are consistent with the Free Flight operational concept, "…a safe and efficient flight operating capability, under instrument flight rules, in which the operators have the freedom to select their path and speed in real time."

All are based on Administrator Garvey's "three essential goals" of modernization:

- Sustain the integrity and reliability of the system.
- Improve on our Nation's excellent safety performance.
- Increase flight efficiency and flexibility.

1.4.1 NAS Architecture

The NAS Architecture responds to the requirements of the *Government/Industry Operational Concept for the Evolution of Free Flight* (CONOPS). The most recent version culminates an intensive effort of the FAA, DOD, industry representatives, and pilot and owners' organizations to define a realistic comprehensive system architecture to meet the infrastructure needs of 21st-century air transportation. The *NAS Architecture Version 4.0* document, approved by the FAA Joint Resources Council on September 14, 1998, was published in February 1999.

The Architecture incorporates the needs and requirements of NAS users and directs an incremental, benefits-driven approach towards the capabilities of Free Flight. It covers the transition from the current NAS through three distinct phases respectively ending in: 2002; 2007; and the year when mature Free Flight is anticipated, 2015. The concept forms the basis for various FAA and user community plans calling for procedural, financial, and architectural decisions regarding capabilities needed for Free Flight.

Before the full Architecture was put together, a NAS Modernization model was used to validate all current and proposed R&D initiatives within the Air Traffic Services (ATS) area. As a result, new requirements were identified, and some ongoing research activities were restructured. Details of how ATS research activities map to NAS Modernization appear in the *NAS Architecture Version 4.0.* As system managers continue to anticipate future needs, they will continue to assess architecture options against the NAS Modernization model and existing capabilities.

1.4.2 Free Flight Initiatives

Free Flight Phase 1

The partnerships, systems, and regulations that will make Free Flight both safe and efficient will be developed in the "phases" described in Section 1.4.1, "NAS Architecture." Free Flight Phase 1 (FFP1) was begun in July of 1998. As a "Phase 1" effort, FFP1 will be completed by calendar year 2002. In its short span of time, FFP1 will deploy its "core capability" prototype systems to selected sites, in specific configurations to demonstrate the potential of adapting known research vehicles to meet the steep capacity and efficiency demands of the Free Flight environment. The FAA and its partners have maintained consensus on the FFP1 core capabilities and their limited deployment (CCLD). They have collaboratively endorsed the statement: "Any activity that removes restrictions represents a move toward Free Flight."

The FFP1 consensus between the FAA and the full aviation community has been extraordinary. RTCA took an early and active role in bringing other partners in industry into the collaborative process. Various committees and task forces operating in the four years prior to the start of FFP1 did a great deal to define the issues and shape the program. The FAA Administrator established the program as a high priority, high visibility undertaking, accountable directly to her office.

The basic goals of FFP1 are to: (1) provide near-term measurable benefits; (2) focus on early delivery of operational capabilities by the year 2002; (3) integrate the capabilities with procedures; (4) utilize "low risk" technologies; (5) use an evolutionary development paradigm; (6) integrate operational, technical, and financial considerations; and (7) measure results (provide metrics) and maintain accountability.

The selected FFP1 capabilities are:

- Traffic Management Advisor (TMA): A tool that aids the enroute controller in making decisions regarding sequencing and spacing of enroute arrival aircraft approaching selected airports.
- Passive Final Approach Spacing Tool (pFAST): A tool that aids the controller in making decisions regarding sequencing and runway assignment for terminal arrival aircraft.
- User-Request Evaluation Tool (URET): A tool that aids the controller in managing enroute traffic, supporting user request decisions, and identifying potential conflicts.
- Collaborative Decision making (CDM): A collection of tools that allows the FAA and participating airlines to exchange NAS status information including weather, equipment and delays.
- Surface Movement Advisor (SMA): A data distribution capability that provides aircraft arrival information to airline ramp towers and permits data exchange to support efficient surface movement.

Figure 1-3 graphically depicts the interaction of the FFP1 CCLDs in all phases of flight.

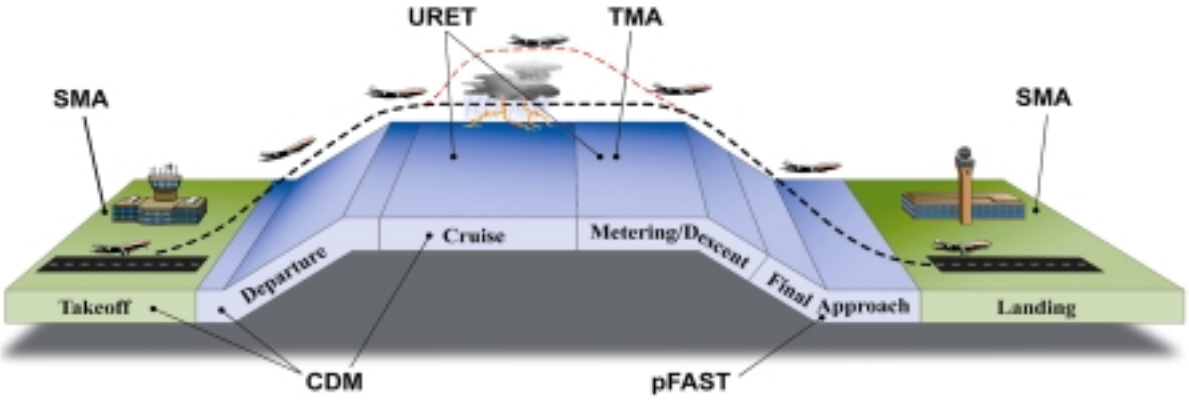

Figure 1-3. Free Flight Phase 1 CCLDs

The Free Flight Phase 1 program represents a strong confirmation of the value of existing and ongoing aviation systems research. The program is now delivering the early benefits and maintaining the metrics required in its charter. As of October 1999, the FFP1 "products" have made impressive progress, including the following:

- TMA: Early prototypes have been deployed to Miami, Los Angeles and Denver Centers; the current build prototype is fully operational at Ft. Worth, where it is being used whenever conditions warrant.
- pFAST: The current prototype has been deployed at Dallas Fort Worth.
- URET: Prototypes have been deployed at Memphis and Indianapolis Centers; two-way host interface operations continue to increase at both centers, indicating increasing controller acceptance.
- CDM: 13 of 21 facilities are configured for Initial Collaborative Routing; the Enhanced Ground Delay Program Flight Schedule Monitor is installed at 27 of 34 field facilities; system-wide, over 3.2 million minutes of delay have been avoided between 9/98 and 9/99.
- SMA: Non-FFP1 prototype still supported in Atlanta; all FY99 milestones were completed ahead of schedule; SMA data is being provided from Detroit (to Northwest Airlines and Southwest Airlines) and Philadelphia (to US Airways).

Safe Flight 21

As with FFP1, Safe Flight 21 is a high-priority Phase 1 activity intended to accelerate the pace and success of NAS modernization. Safe Flight 21 has replaced and redefined the Flight 2000 program. With the collaboration of the aviation industry, the program has targeted nine communications, navigation, and surveillance operational enhancements to deploy and evaluate within the Ohio Valley, in Alaska, or in both locations. The results will provide a basis for future FAA policies and decisions regarding the selected technologies and procedures.

By the end of FY 2000 the Safe Flight 21 Program Office intends to procure and install Automatic Dependent Surveillance – Broadcast (ADS-B) ground stations; Flight Information Services (FIS) and the Automated Weather Observation System (AWOS) in Alaska; and avionics in FAA and Alaska aircraft. In this same time frame, the staff will complete an evaluation of the three selected ADS-B links, submit their recommendations regarding optimal link choices, and begin to develop related procedures.

1.4.3 New Safety and Security Initiatives

Safer Skies

In 1997 the President's Commission recommended the FAA launch a concentrated effort to reduce accidents fivefold over the next decade. The National Civil Aviation Review Commission (NCARC) concurred and further advised that the FAA work with industry on safety data analysis. Later that year, Administrator Garvey committed the agency to developing a five-year plan to focus its resources on the accident prevention steps that hold the greatest potential. "Safer Skies" was the result. The essence of the initiative was to look at available data and to draw lessons from it—a pointed, pragmatic research emphasis.

Vice President Gore announced the new initiative, "Safer Skies—A Focused Agenda," on April 14, 1998. Under this agenda, the FAA pledged to review available data on all major causes of aviation accidents and, where necessary, refocus its safety priorities. Just a year and a day later, Administrator Garvey was able to report to a conference of industrial participants that 230 aircraft of 13 types were collecting Flight Operations Quality Assurance (FOQA) data and 350 additional aircraft were being equipped for FOQA.

Safer Skies has focused initially on three areas: commercial aviation, general aviation, and cabin safety. In just one year, eight final rules have been published in the *Federal Register* regarding the prevention of uncontained engine failures. Another rule soon will require that passenger aircraft carry warning systems to lessen the dangers of Controlled Flight into Terrain. New standards, awareness training for controllers, and special training for pilots are imminent. The potential for Safer Skies operational insights is very promising.

Fielding of Security Equipment

Since the early 1990s, the FAA Aviation Security R&D Program has been highly responsive to congressional mandates, as well as the Gore Commission, to expedite the passage from research to the field of cheaper, more reliable aviation security technologies. To date, the FAA Security Equipment Integrated Product Team has advanced the protection of the traveling public by deploying over 531 explosive trace detection devices to U.S. airports. The team already has completed 92 installations of one vendor's advanced explosives detection system (EDS) installations, with more scheduled for FY2000. A recent competitor's EDS was certified in October 1998, and by the end of FY2000, certification of a third vendor's system is anticipated. The agency works closely with its industry partners to encourage constructive competition, to decrease the costs, and to increase the reliable capabilities of fieldworthy systems.

Various types of systems are in, or are nearing, prototype stages to mitigate the security threats involving the full range of aviation facilities and situations. Examples include checked baggage screening technologies, checkpoint technologies, cargo screening technologies, and systems designed for small volume vs. large volume airports and other facilities. While automated solutions are preferred, standards and training programs are being developed to screen and train the airport and airline employee operators of systems.

Aging Aircraft Systems

On October 1, 1998, DOT Secretary Rodney Slater and FAA Administrator Garvey announced a new initiative that will help ensure that aircraft systems such as wiring and fuel do not fail as they age. This program, called the Aging Transport Nonstructural System Plan, includes stepped-up inspections of wiring, a long-term research program, and a model-by-model assessment of each aircraft type. The initiative was undertaken in response to the mandate of the Gore Commission.

The FAA's nonstructural aging aircraft program combines regulatory actions, focused inspections, research, training, and advice from the aviation community. It includes seven initiatives to enhance the safety of nonstructural aircraft components:

1. Establish an Aging Transport Systems Advisory Committee to coordinate the Plan's initiatives.

2. Conduct an in-depth review of the aging transport fleet and make model-specific safety recommendations related to airplane systems.

3. Enhance airplane maintenance to better address aging airplane systems.

4. Add aging systems tasks to the FAA research program.

5. Improve reporting of accident/incidents and maintenance actions involving aircraft wiring system components.

6. Evaluate the need for additional maintenance of transport airplane fuel system wiring and address any unsafe conditions.

7. Improve wiring installation drawings and instructions for continuing airworthiness.

In recent years, the Aging Aircraft Program has constructed one state-of-the-art testing facility and added to another. The new full-scale aircraft structural test evaluation and research facility at the William J. Hughes Technical Center examines full-scale curved panel specimens under actual operating conditions and provides data to validate the FAA's analytical models. The expanded Airworthiness Assurance Nondestructive Inspection Validation Center, in Albuquerque, New Mexico, compares and evaluates the effectiveness of inspection, maintenance, and repair techniques. The program also has begun several data collection programs and data surveys to determine the actual effects of wear upon aircraft under routine operating conditions.

1.5 Research Partnerships

1.5.1 National Science and Technology Council

President Clinton established the National Science and Technology Council (NSTC) by Executive order on November 23, 1993. This Cabinet-level Council is the principal means by which the President, who chairs the NSTC, can coordinate science, space, and technology among the diverse parts of the Federal research and development enterprise. Council members include the Vice President, Assistant to the President for Science and Technology, Cabinet Secretaries and Agency Heads with significant science and technology responsibilities, and other White House officials.

A key NSTC objective is to establish clear national goals for Federal science and technology investments that can strengthen and improve areas ranging from information technologies and health research to transportation systems and fundamental research. The Council prepares research and development strategies that are coordinated across Federal agencies to form an investment package aimed at accomplishing multiple national goals.

The NSTC Committee on Transportation Research and Development chaired by Deputy Secretary Mortimer Downey has developed the rationale and framework for guiding Federal initiatives that will make the transportation system safer, more productive, and more efficient. Considering the likely future, the Transportation R&D Committee has defined these strategic goals for transportation R&D:

- Provide a safer transportation system.
- Achieve a high level of transportation system security.
- Improve environmental quality and energy efficiency.
- Foster economic growth and productivity through more effective and flexible global passenger and freight services.
- Ensure improved access to and increased mobility on the Nation's transportation system.

The FY 2001 FAA R&D budget supports these strategic goals for transportation R&D in the NSTC plan. The FAA is a highly visible member of the transportation community. Continuing investments in its research activities are critical to meeting the national goals and sustaining the prosperity of the national economy.

In its recently published report titled "*National Research and Development Plan for Aviation Safety, Security, Efficiency, and Environmental Compatibility*" (1999), the Council provides a description of the coordinated long-term research initiatives it believes are needed to bring about the advances in aviation for the opening decades of the next century. The report is available on the internet at:

http://www.volpe.dot.gov/resref/strtplns/nstc/aviatrd

1.5.2 FAA/NASA Collaborative Research

FAA/NASA Safety Program

The pace of aviation is changing so rapidly that, in less than two decades, there could be a fatal airline accident somewhere in the world every week — unless the FAA and its research partners lower the accident rate. Technology has always held the key to maintaining commercial aviation's impressive safety record, but in an increasingly complex world, the search for technologies requires increasing discipline. The wrong technologies, employed in the wrong ways, could introduce more problems than they solve.

On October 9, 1998, FAA Administrator Jane Garvey and NASA Administrator Daniel Goldin signed a formal agreement to articulate and achieve specific joint goals enabling the NAS to meet its future challenges. The agencies have long worked together through Memoranda of Understanding on specific topics such as human factors, aging aircraft, aircraft icing, airworthiness of new classes of aircraft, crashworthiness, energy efficiency, and noise reduction. Since 1980, each of the agencies has provided members to a common R&D coordinating committee. With the 1998 agreement, that committee was restructured into a new "FAA/NASA Executive Committee" and charged with coordinating all joint R&D efforts.

The FAA has traditionally developed and implemented technologies, regulations, and procedures based upon its supporting research. These innova-

tions have provided operational benefits to areas including security, efficiency, and environmental compatibility, in addition to safety. NASA has complemented FAA's role by conducting research, development, verification and transfer of advanced technologies that have enabled long and short-term NAS improvements. These remain the roles emphasized for the agencies by the 1998 agreement.

The recent NSTC National R&D Plan (cited in Paragraph 1.5.1 of this Plan) provides an "Aviation Safety Roadmap" of the inter-agency plan to achieve the national goal for safety. The initiative has three primary thrusts and entails the following research issues:

Accident Precursor Identification and Safety Risk Management — Accidents rarely have a single cause. Aviation systems and procedures, accordingly, are developed to be redundant and failure-tolerant. Many accidents can be avoided by detecting and responding to anomalous operating conditions. The FAA is looking into means to obtain data for the prevention of accidents through its Aviation Safety and Risk Analysis (ASRA) program. NASA's Aviation System Data Monitoring and Modeling (ASMM) program identifies tools and methodologies that not only can analyze situations today but also foresee the future safety impact of today's changes to key systems. Jointly, the agencies are working to develop the Aviation Performance Measuring System (APMS) to help all segments of the aviation community draw safety implications out of the data now being collected as a normal part of fleet operations.

Accident prevention — The FAA conducts research to help it establish safety-related rules, regulations, and advisory materials. Through its research, NASA identifies and develops on-board and system-wide technologies that can keep aircraft safe. FAA is working closely with industry in aviation safety areas including the improvement of propulsion and fuel systems, the prevention of aircraft catastrophic failure, the elimination or containment of in-flight fires, and the creation of safer airport materials and systems. NASA research is upon technologies to afford better visibility to pilots and flight crews experiencing adverse conditions, to improve the overall health of pilots and crews, and to allow pilots to regain control of their aircraft when engines or systems fail in flight. Together with DOD, the FAA and NASA are working to improve the effectiveness of their long-term commitment to the Aging Aircraft program.

Accident Mitigation — When aviation accidents do occur, their effects can be lessened through attention to factors such as aircraft crashworthiness, occupant protection, fire safety, evacuation equipment and procedures, and airport emergency services. The FAA is conducting detailed and innovative aeromedical research to improve the chances that more passengers and crew members will survive aviation accidents. The agency also works to improve airport systems to provide better materials, methods and equipment to increase survival rates. NASA partners with the FAA on research to improve the structural crashworthiness and the fire resistance of aircraft and fuels.

Integrated Plan for Air Traffic Management for Research and Technology Development

On September 11, 1995, the FAA and NASA strengthened their partnership by signing a Memorandum of Understanding on Airspace System User Operational Flexibility and Productivity, thus initiating the formation of the FAA/NASA Interagency Air Traffic Management (ATM) Integrated Product Team (IAIPT). ATM encompasses air-based and ground-based air traffic control and traffic flow management decision support tools and procedures. This cooperative relationship was reaffirmed on October 9, 1998 with the signing of the "Agreement Between DOT/FAA and NASA Concerning a Partnership to Achieve Goals in Aviation and Commercial Space Transportation."

The stated mission of the IAIPT is to maintain the safety of aircraft operations for the current and future NAS while planning and conducting integrated FAA/NASA ATM R&D leading to the implementation of operational concepts and associated decision support tools that enhance the efficiency, capacity, and flexibility of the National Airspace System.

The IAIPT is comprised of the major stakeholders in the planning, execution, and outcome of ATM R&D programs, throughout the FAA and NASA.

As illustrated in Figure 1-4 below, the three major elements of the IAIPT are: 1) the IAIPT Co-Leads, 2) the Interagency Integrated Management Team (IAIMT), and 3) Area Work Teams (AWT).

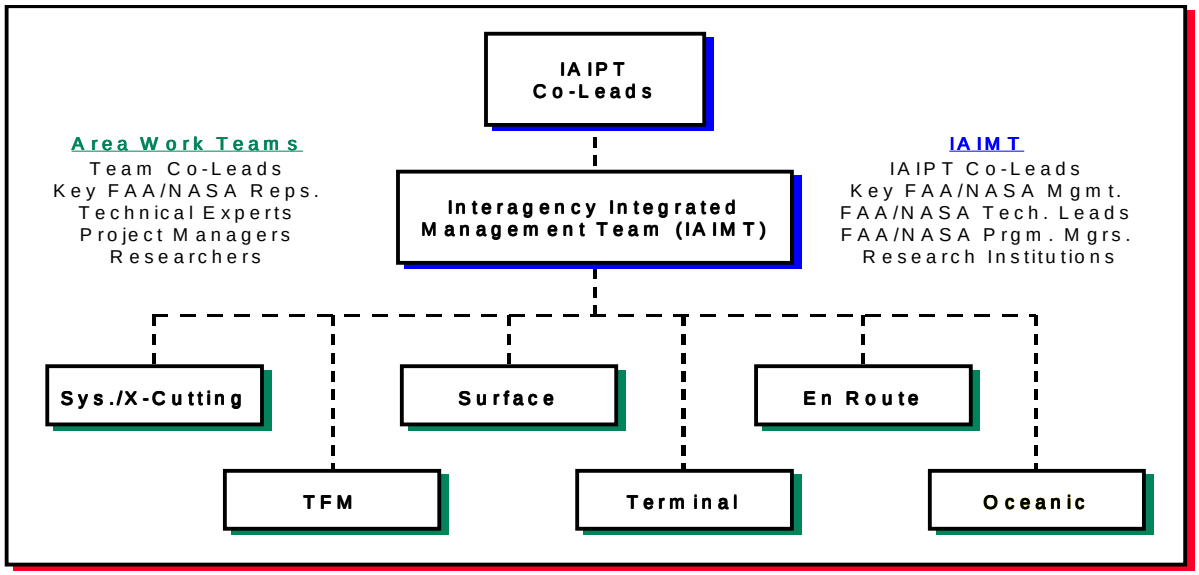

Figure 1-4. IAIPT Organization

The IAIPT Co-Leads strategically formulate R&D policy and goals that effectively position the IAIPT to achieve its mission. The IAIMT ensures that R&D outputs result in highly useful ATM products for customers and stakeholders. The AWTs execute specific research activities in each of the research areas encompassed by the IAIPT. Together, these elements provide structure and means for communications and resolution of issues as well as integration across research domains.

IAIPT receives guidance from the FAA R,E&D Advisory Committee (REDAC), its Subcommittee on Air Traffic Services, the NASA Aeronautics and Space Transportation Technology Advisory Committee, and the NASA Air Traffic Management Research and Development Executive Steering Committee. Through its respective FAA and NASA organizations, the IAIPT also maintains collaborative partnerships with Federally-Funded Research and Development Centers, industry, academia, Department of Defense, Eurocontrol, the Center of Excellence in ATM and Operations Research, the National Weather Service, and research contracts.

The principal defining documents for the IAIPT are the *Integrated Plan for Air Traffic Management Research and Technology Development* (Version 3.0) and the *Management Plan for the FAA/NASA Interagency Air Traffic Management Integrated Product Team* (Version 1.0b). The six IAIPT AWTs, representing the technical domains of ATM R&D, are as follows:

- *System/Cross-Cutting*—System-wide initiatives, including the initial definition of concepts and assessment methodologies and demonstrations of cross-domain system(s) integration (e.g., enroute, terminal, and surface decision support systems).
- *Traffic Flow Management*—Strategic resource allocation and flow management.
- *Surface*—Operations on an airport's surface.
- *Terminal*—Operations in airspace surrounding one or more closely spaced airports where a TRACON or a comparable military facility provides services.
- *En Route*—Operations in airspace between airports where an ARTCC provides services,

and transition airspace between the enroute and terminal environments.

- *Oceanic*—Operations in airspace over international waters where an oceanic ARTCC provides services.

The IAIPT periodically reports to the FAA Associate Administrator for Research and Acquisitions and the NASA Associate Administrator for Aerospace Technology through the FAA/NASA Coordinating Committee. Specific program direction and control comes through internal program management mechanisms in both agencies.

Joint ATM research is accomplished through Joint Research Project Descriptions. Currently, 22 JRPDs comprise the IAIPT research program and are contained in the IAIPT Integrated Plan. IAIPT research is accomplished at the following research facilities: FAA William H. Hughes Technical Center, NASA Ames Research Center, NASA Langley Research Center, MITRE CAASD, MIT Lincoln Laboratory, Volpe National Transportation Systems Center, and NASA North Texas Research Station.

All of FAA's current Free Flight Phase 1 core capabilities for limited deployment (see Section 1.4.2) have successfully been transitioned from former IAIPT products.

IAIPT joint FAA and NASA near- and far-term research is currently being conducted on the products shown in Table 1-2.

Table 1-2 Current and Envisioned FAA/NASA IAIPT Products

IAIPT Product	Description (if available)
Multi-Center Traffic Management Advisor (McTMA)	Provides aircraft sequencing and scheduling to enable efficient departure taxiing and climbs.
Surface Management System (SMS)	Advises airlines, ramp controllers, and air traffic control on push-back and taxi navigation for efficient surface operations.
Expedite Departure Path (EDP)	Coordinates departure sequencing and scheduling to enable efficient departure taxiing and climbs.
Collaborative Routing Coordination Tool (CRCT)	Vehicle for making collaborative decisions concerning flow-constrained areas and impacted flights.
Collaborative Arrival Planner (CAP)	Communicates airline operation center user preferences and arrival handling preferences to air traffic control.
Future Collaborative Decision Making Tools	Improved demand and constraint prediction algorithms and enhanced integration of weather predictions into strategic traffic flow planning.
Distributed Air-Ground Traffic Management (DAG)	Provides distributed decision making information to flight deck crews, air traffic service providers, and aeronautical operations control facilities to enable user preferences and increase system capacity.
Airborne Planner to Avoid Traffic & Hazards (APATH)	Provides aircraft flight crew with tactical situational awareness of surrounding traffic enabling efficient self-separation.
Active Final Approach Spacing Tool (aFAST)	Provides arrival aircraft speed and heading advisories to the TRACON arrival controllers.
Direct-To (D2)	Advises sector controllers of time saving direct routing options for aircraft within an ARTCC.
Problem Analysis, Resolution, and Ranking (PARR)	Provides conflict resolution enhancements to User Request Evaluation Tool (URET) that enable strategic detection of conflicts and support user request decisions.
En Route Descent Advisor (E/DA)	Provides advisories to ARTCC sector controllers on merging, sequencing, and spacing of aircraft for efficient climb, cruise, and descent constraint and flow management.

The IAIPT Integrated Plan is available on the Internet:

ftp://awaauatac2.faa.gov/IAIPT_Main/
IAIPT_Public/

1.5.3 Cooperative Research

The work described below is representative of partnering between the FAA, NASA, and primary DOD components in planning, funding, and the use of cooperative agreements.

Aircraft Modification and Improvement Research

FAA programs to improve the initial and continuing airworthiness and survivability of aircraft have benefited from the interest and support of the DOD service branches. The Aging Aircraft program develops information and procedures for using technologies that can predict the onset of failures of aircraft structures under a range of operating conditions.

In addition to FAA and NASA sponsorship, this program receives significant U.S. Air Force funding. The Air Force and FAA are co-participants in funding the Fire Research and Safety program and its efforts to standardize and improve the testing of fire-resistant materials for use in aircraft interiors. Similarly, the Aircraft Hardening program relies on significant U.S. Navy participation to develop protection for aircraft against catastrophic structural or critical system failures resulting from in-flight explosions or the effects of electronic interference.

DOD also is vitally interested in the development of flight standards underlying the Safety Performance Analysis System (SPAS), which provides FAA stakeholders with critical safety-related data on the design, maintenance, and operation of their aircraft.

Human Factors Research

Along with FAA and NASA, DOD is a primary participant in publishing the *National Plan for Civil Aviation Human Factors—An initiative for Research and Application*. This document outlines a coherent national agenda for human factors research and application leading to significant improvements in NAS safety and efficiency. Programs stemming from this and similar research plans have developed and provided useful information to FAA stakeholders on the effects of human performance on aviation operations, navigation, aircraft maintenance, and other matters of importance to commercial and military aviation. Section 1.7.1 of this Plan provides an overview of some of the sophisticated human factors research projects being carried out at the FAA's William J. Hughes Technical Center and Civil Aeromedical Institute.

1.5.4 Centers of Excellence

Air Transportation Centers of Excellence (COE) are established through cooperative agreements among academic institutions, their affiliate partners, and the FAA. COEs are established to assist the FAA in the pursuit of mission-critical research in technologies that are pertinent to developing and maintaining a safe and efficient national air transportation system. Centers may be funded in 3 phases over a period of three to ten years. Thereafter, they are expected to be self-supporting.

Center of Excellence in Airworthiness Assurance

The Center in Airworthiness Assurance was established with Ohio State University and Iowa State University as leads and seven additional core members. There are more than 100 academic, industry, and government affiliate partners.

The center, established in September 1997, conducts research in the areas of:

- Maintenance, inspection, and repair.
- Crash-worthiness.
- Propulsion and fuel systems performance.
- Safety.
- Advanced materials.

Funded through contracts and grant awards, this center has a $100M contract cap over the next ten years and is making a $500K per year minimum commitment to fund basic and advanced research through a cooperative agreement.

Center of Excellence in Operations Research

The FAA-selected team of the University of California (Berkeley), Massachusetts Institute of Technology, Virginia Polytechnical Institute, and the University of Maryland (College Park) are the leads for the Center of Excellence in Operations Research. This team includes ten university affiliates and twenty industrial partners. The COE program uses a new funding vehicle blending grant and sole-source contracting authority to award a wide range of contracts. The center's areas of re-

search involvement include traffic management and control, human factors, system performance and assessment measures, safety data analysis, scheduling, workload management and distribution, navigation, communications, data collection and distribution, and aviation economics.

Center of Excellence for Airport Pavement Research

The Center of Excellence for Airport Pavement Research was established with the University of Illinois (Urbana-Champaign) in April 1995 and is supported by Northwestern University. Pavement research focuses on new technologies to handle the estimated stress loads foreseen in the next generation of high-volume, commercial aircraft, such as the Boeing 777. This research, including rehabilitation and non-destructive testing and evaluation of existing pavement, is conducted at the former Chanute Air Force Base, Rantoul, Illinois.

1.5.5 European Activity

Global harmonization of communication, navigation, surveillance, and air traffic management (CNS/ATM) technologies and standards holds the key to the future success of all aviation systems. The United States (through the FAA) continues to position itself to be a leader in international efforts to maintain the safety, security, efficiency and environmental compatibility of civil aviation. Progress towards a globally harmonized CNS/ATM system has accelerated since the adoption of the Global Plan for CNS/ATM Implementation by the International Civil Aviation Organization's (ICAO) Tenth Air Navigation Conference.

The FAA has continued to support CNS/ATM implementation by participating in ICAO technical panels, committees, study groups, and regional planning groups as well as by entering into numerous bilateral cooperative research and development agreements with countries and civil aviation organizations in every region of the world. These ICAO forums and international agreements provide the FAA opportunities to work directly with key research, engineering, and development organizations and decisionmakers in order to make significant contributions toward international coordination of air traffic services.

The FAA also works closely with internationally recognized standards developing organizations such as RTCA and the European Organization for Civil Aviation Equipment (EUROCAE) to reach consensus with industry and the user community on standardizing and certifying evolving aviation technologies.

1.6 Overview of the R,E&D Program

The FAA RE,&D program is divided functionally into seven areas: Air Traffic Services, Airport Technology, Aircraft Safety, Aviation Security, Human Factors and Aviation Medicine, Environment and Energy, and R,E&D Program Management.

- *Air Traffic Services*—R&D focuses on increasing system safety and capacity and enhancing the flexibility and efficiency of air traffic management operations. A key element in achieving these objectives is developing decision support tools that will enable FAA air traffic specialists to manage traffic flows more efficiently while collaborating with the user community in making decisions affecting their operations.

  The R&D program is also working to reduce the risks of runway incursions, midair collisions, and aircraft encounters caused by the effects of wake vortices and hazardous weather. Research is developing new technologies that will improve navigational accuracy and provide improved landing guidance. Communication research develops technologies that improve the reliability of pilot-controller communications and permit the exchange of large data files, such as weather data, to pilots.

  The FAA is introducing new technologies to support a Free Flight system, in which aircraft operators could vary their speed and flight path to increase operational efficiency, while air traffic controllers ensure that safety is maintained.

- *Airport Technology*—R&D develops and evaluates technologies and materials designed to ensure and improve safe and efficient operations on the airport surface and in the imme-

diate vicinity of an airport. Research focuses on development and evaluation of advanced, innovative technologies involving pavement design, construction, and maintenance; airport visual and navigation aids; rescue and firefighting equipment and procedures; runway friction; and wildlife control techniques. Research results are used to update FAA standards for the design, construction, and operation of airports and airport equipment, and are incorporated into guidance material used by airport operators, consultants, and equipment manufacturers.

- *Aircraft Safety*—R,E&D focuses on ensuring the safe operation of inservice aircraft. It addresses the hazards to all aircraft in service, as well as the special hazards endemic to select portions of the civil aircraft fleet. Older aircraft are more susceptible to structural problems associated with fatigue and corrosion. New aircraft with digital flight control and avionics systems and associated imbedded software are more susceptible to disruption from external electromagnetic interference. Research focuses on developing technologies and standards for maintenance and modification of inservice aircraft to ensure continued airworthiness. It includes research in structural integrity of airframes and engines, maintenance and repair of composites, atmospheric hazards, crashworthiness, fire safety, and forensics capabilities to support accident investigations.
- *Aviation Security*—R&D develops technologies and standards that counter the threat of terrorism and criminal acts targeted at aviation. Research focuses on developing and evaluating passenger, baggage, mail, and cargo screening devices to detect concealed explosives and weapons; aircraft hardening techniques to increase aircraft survivability in the event of an inflight explosion; human factors aspect of detection and alarm resolution; and integration of airport security technologies and procedures. An important consideration in this research is to develop effective, reliable technologies and procedures that have minimal impact on airport and airline operations.
- *Human Factors and Aviation Medicine*—R,E&D directly supports the National Plan for Civil Aviation Human Factors and the validated needs of the FAA's lines of business and NAS users. The program addresses major human factors priority areas related to the flight deck, ATC, flight deck/ATC system integration, airway facilities, aircraft maintenance, and aeromedical aircraft cabin environments.
- *Environment and Energy*—R&D develops technical information, standards, and procedures to mitigate the environmental impact of aircraft operations (in particular, noise and air pollution emissions), and to better understand and manage the impact of FAA operations on the environment.
- *R,E&D Program Management*—includes the management, planning, control, and support activities associated with formulating the FAA R&D program. These efforts ensure that the program is a cohesive and integrated effort, consistent with the FAA strategic goals and objectives, and fully coordinated with stakeholders and customers.

This cross-cutting emphasis ensures outside assessment of the FAA R&D investments through active participation of the FAA R,E&D Advisory Committee. The members of the committee represent industry, academia, and other government agencies. R,E&D Program Management also facilitates research partnerships with industry, universities, and other government agencies that enable the FAA to leverage its research dollars.

1.7 Long-Term Research

The Research, Engineering, and Development Management Reform Act of 1996 directed the FAA to identify the allocation of resources among long-term research, near-term research, and development activities.

Long-term research, as defined in the Aviation Safety Research Act of 1988, is a research project that is "unlikely to result in a final rulemaking action within five years, or in the initial installation

of operational equipment within 10 years after the date of the commencement of such project."

The FAA's R&D is principally associated with applied research. That is leveraging off new technologies identified by research programs in space, aeronautics, communications, computer science, and other related fields of exploration. Developmental activities beyond this stage are found in the Engineering, Development, Test, and Evaluation activity of the FAA's Facilities and Equipment (F&E) appropriation.

Of the $156,495M appropriated for R&D efforts in FY 2000, 28% of these funds are earmarked for long-term research, with the remainder devoted to developmental/near-term efforts. Similarly, the $184,366M FY 2001 congressional budget submission for R&D designates 23% of the total request for long-term research.

1.7.1 FAA Aviation Research Centers

The FAA maintains two permanent, world-renowned research centers, The Civil Aeromedical Institute, located in Oklahoma City, Oklahoma, and the William J. Hughes Technical Center, located adjacent to the Atlantic City International Airport in New Jersey.

Civil Aeromedical Institute

The Civil Aeromedical Institute (CAMI) is a unique, internationally recognized aeromedical facility located at the Mike Monroney Aeronautical Center in Oklahoma City, Oklahoma. CAMI maintains a cadre of in-house scientific specialists whose safety research thrusts are all distinctively human-centered and include:

- *Advanced ATC Systems Research* — Using rapid prototyping techniques with advanced real-time ATC simulation capabilities, scientists analyze advanced ATC system designs and their effects on workload and performance, develop metrics of performance and workload, assess the applications of innovative control and design concepts, and identify and evaluate the applications of intelligent systems to enhance aviation safety.
- *Behavioral Stressors Research* — Human factors researchers investigate variables that could compromise safety by impairing both ATCS and pilot job performance levels (e.g., shift management, age, fatigue, drug and alcohol induced impairment, color perception) and assess the effectiveness of policies, procedures, individual coping strategies, and countermeasures to reduce performance decrements and enhance individual performance.
- *Organizational Effectiveness Research* — Through field research, analytic information is developed to measure progress toward achieving agency change goals and for agency guidance on the relative merits of various innovations intended to enhance safety, efficiency, effectiveness, workforce health and satisfaction, and system performance. Relationships between psychological characteristics (e.g., work attitudes, organizational perceptions) and the work environment (e.g., business practices, organizational climate) are explored.
- *Flight Crew Performance Assessment* — General Aviation research emphasizes design of flight deck controls and displays related to emerging technology, development and validation of performance-based criteria for use in certification and regulation, and the successful integration of training devices into existing instructional systems to enhance flight crew performance and reduce accidents and incidents.
- *Selection, Validation, Research and Team Performance* — Researchers use laboratory and field studies to develop scientific evidence of the job validity of criteria within aviation selection and training systems. Cognitive strategies and processes underlying aviation skill acquisition through training are identified and assessment measures of individual and team performance developed to determine effects of advancing technologies on individual and workteam safety, efficiency, and effectiveness.
- *Aircraft Accident Research* — CAMI scientists maintain comprehensive databases and conduct extensive analyses involving the human factors, medical, physiological, and pathological aspects of aviation mishaps. Preventive measures and proactive interventions that will enhance aviation safety in the next millennium are rigorously investigated.

- *Forensic Toxicology Research* — Impeccable procedural integrity and robust toxicological and biochemical analyses of human samples from fatal aircraft accidents are required in support of the National Transportation Safety Board to ensure continuous safety of the NAS. Scientists evaluate the underlying human basis of mishaps to prevent future human tragedy in our transportation systems. State of the art analytical and molecular biological techniques, including DNA analyses, are developed to assist in identifying human causes or influences associated with aviation fatalities.
- *Biodynamics Research* — When failures do arise in aviation, occupant survival may depend directly upon the design of the seating and restraint systems in the aircraft. Evaluating the design of these systems and ensuring their protective characteristics requires both scientific and engineering talents.
- *Cabin Safety Research* — The ability to survive following aircraft related emergencies depends upon the systems, structures and procedures that are developed and investigated in CAMI's aircraft evacuation facility where researchers conduct occupant evacuations from current aircraft configurations and develop evacuation research for larger, more complex aerospace vehicles of the future.
- *Aviation Environment Safety Research* — Breathing and oxygen delivery systems for all aircraft occupants in normal and emergency situations are investigated. Threats to visual integrity and pilot performance from intense light emitters and ground-based lasers are defined. Improved measures of galactic cosmic radiation levels at various altitudes are developed by CAMI scientists to ensure that those who work and travel in the aviation system are not at a disproportionate risk for health problems from radiation exposures.

William J. Hughes Technical Center

The FAA William J. Hughes Technical Center (WJHTC) is one of the world's leading engineering, research, development, and testing facilities for nearly every aspect of aviation. Representative areas of involvement of this diverse and extensive facility include:

- *NAS Modernization* — The center uses currently fielded and newly developed systems to perform R&D encompassing every aspect of air traffic operations. Its laboratories contain current and advanced radar display systems capable of intricate simulations for the testing, development, and evaluation of both air and ground traffic procedures and enroute operational concepts.
- *Services and Operations* — Every NAS service provided by the FAA is either on-site or accessible at the center. The Integration Interoperability Facility (I^2F) allows staff to simulate actual operating conditions, including adverse weather, to test and evaluate systems without impacting air traffic operations or ARTCC site personnel.
- *Air Traffic Management* — The powerful capability of the Traffic Flow Management Laboratory allows for a "fast-tracked" development approach ideal for meeting escalating NAS modernization needs without extensive, traditional prototyping.
- *Human Factors* — The multiple "what if" capabilities of the Research, Development and Human Factors Laboratory apply principles derived from the behavioral sciences to plan and test the deployment of next generation NAS capabilities such as displays and workstations. As NAS modernization will increasingly rely on the automation of suitable tasks, improved and reliable computer-human interfaces are critical to the avoidance or mitigation of system-induced operator errors.
- *Navigation and Surveillance* — WJHTC scientists conduct flight tests with actual GPS signals and prototype ground stations to maximize GPS accuracy in connection with LASS and WASS capabilities. Similarly, they perform tests and evaluations of Automatic Dependent Surveillance — Broadcast capabilities to provide reliable aircraft position data to airborne and ground-based users.
- *Communications* — Simulation and live research is being performed to improve the reliability of both voice and digital data (data link) transmission.
- *Terminal Areas* — The improvement of airports' capacity is a difficult problem facing

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